Modular Seat Cushion with Interlocking Human Support and Base Portion and Method of Creating and Using a Seat Cushion

Cross-Reference to Related Applications

This invention is related to other inventions made by at least one of the inventors herein for Individually-Contoured Seat Cushion and Shape Capturing and Fabricating Method for Seat Cushion described in U.S. patent application Serial No. [249.301], and for Contoured Seat Cushion and Method for Offloading Pressure from Skeletal Bone Prominences and Encouraging Proper Postural Alignment described in U.S. patent application Serial No. [249.303], and for Apparatus and Method for Evaluating Clearance from a Contoured Seat Cushion described in U.S. patent application Serial No. [249.304], all of which are filed concurrently herewith and all of which are assigned to the assignee of the present invention. The subject matter of these concurrently-filed applications is incorporated herein by reference.

Field of the Invention

This invention relates to seat cushions, and more particularly, to a new and improved modular seat cushion formed by a human support portion and an interlocking base portion. The human support portion provides individualized support for the user, and the base portion fits with, is accepted by, or becomes part of a seat support structure. By forming the seat cushion in this modular form, improved support, utility and comfort is available to the user for a relatively modest cost. The present invention is particularly useful to create seat cushions for wheelchairs, although the broader aspects of the invention are not limited specifically to such use.

Background of the Invention

A wheelchair seat cushion must perform a number of important functions. The seat cushion should be comfortable and capable of providing proper support for optimal posture and posture control for a considerable length of time. The seat cushion should also assist, or at least not materially hinder, the user in

maneuvering the wheelchair, permit a useful range of motion from the pelvis and upper torso of the person, and create stability and security for the person within the wheelchair. Perhaps most importantly, the seat cushion should help prevent and reduce the incidence of pressure ulcers created by prolonged sitting on the cushion without adequate pressure relief. Pressure ulcers can become a very serious health problem for individuals who must remain constantly in contact with the support cushion, and it is important to avoid such pressure ulcers.

Wheelchair users like everyone are of substantially different sizes, weights and shapes. Many wheelchair users have physical disabilities and associated posture and postural control impairments such as those typically caused by congenital disorders. Other wheelchair users, such as those who have been disabled by acquired or traumatic injuries, may have a more typical size and shape. In all of these cases, the support contour of the wheelchair seat cushion must safely support the anatomy of the user, whether the anatomy is abnormal or more typical. Wheelchair seat cushions must fit and perform properly to prevent further physical impairment and pressure ulcers. The cushion must also enhance the functional capabilities of the user by supporting independence in activities of daily living. There are a number of different theories or approaches for configuring the support contour of a wheelchair seat cushion to avoid pressure ulcers and to provide adequate postural alignment.

A variety of different wheelchairs are also available. Many of these different wheelchairs have physically different constructions and shapes. The seat support structures of these wheelchairs may vary substantially. One type of wheelchair seat support structure is a sling seat. A sling seat is made of fabric material that is suspended between two frame rails of the wheelchair. The wheelchair cushion is placed on top of the sling seat. A sling seat will bend or sag downward due to the weight of the user and its flexible nature. A platform seat is another type of wheelchair seat structure. A platform seat is generally a flat and rigid structure which is connected on top of the wheelchair frame rails. The cushion is placed on top of the platform seat. A drop seat is similar to a platform seat, except that the platform is located and suspended below the frame rails. A drop seat positions the

person closer to the ground and creates a slightly lower center of gravity for the wheelchair and user. Shell seats and pan seats may also be used as wheelchair seat support structures. A shell seat is a single chair-like shape having a seat bottom and a seat back. In general, a shell seat is used when the wheelchair user is incapable of supporting himself or herself. A pan seat is similar to the seat bottom of a shell seat or to a curved platform seat. A pan seat may be used under special circumstances where other types and forms of wheelchair seat supports are not appropriate or preferred.

To provide the best wheelchair cushion for a user, the cushion must be designed to accommodate and support the anatomy and functional preferences of the user, as well as the type of seat support structure preferred by the user. In general, the predominant previous approach to accommodating these requirements has involved using generic wheelchair cushions which have some capability of adapting to the anatomical shape of the user and then rigging an attachment of the cushion to the wheelchair. The ability of the cushion to adapt to different users is often accomplished by soft, flowable or adaptable cushion material which redistributes under the weight of the user to accommodate the different anatomical shapes of different users. The attachment of the cushion to the wheelchair usually requires additional use of auxiliary attachment devices and hardware which must oftentimes be specifically fabricated for that purpose.

Generic seat cushions may not be comfortable or offer the best fit for a particular user. The size, posture and anatomical characteristics of an individual may influence the comfort and fit of the seat cushion. Certain of these anatomical areas have a prominent skeletal bone structure. Excessive pressure in the areas of prominent bone structure increases the risk of pressure ulcers which can have very serious medical consequences. The problems of existing seat cushions are discussed more completely in the concurrently filed U.S. patent application Serial No. [249.303] referenced above.

Having a custom wheelchair cushion built to accommodate the anatomy and preferences of a specific individual is an option which overcomes the disadvantages associated with generic wheelchair cushions. There are a number

of very sophisticated methods and devices available to create custom wheelchair cushions, but the ability to capture and use the anatomical shape of the user when creating the cushion is very important, as discussed in U.S. patent application Serial No. [249.301] referenced above. Furthermore, even if the support contour of the custom cushion is initially satisfactory, that support contour may ultimately prove to be inappropriate or uncomfortable after the cushion has been used for some period of time. Tissue changes influenced by continually sitting on the cushion over some period of time may change the optimal support and comfort characteristics. It is also typical that tissue may atrophy over time, particularly for first-time wheelchair users, further compromising cushion fit.

Another problem with custom wheelchair cushions is that the user is not able to test or try the cushion before it is fabricated. The user cannot evaluate the support from the cushion and cannot evaluate the seating position in the wheelchair. If the cushion positions the user too far forward or rearward, or too low or high, the ability of the user to turn the drive wheels and maneuver the wheelchair is adversely affected. Turning the drive wheels also causes the pelvis and torso of the user to rock forward and backward. This movement is normal and desirable, but may increase the shear forces experienced at the seat interface thereby further elevating risk for skin breakdown and pressure ulcers.

The cost of a custom wheelchair or cushion can also be a substantial detriment. Creating a custom wheelchair cushion may cost in the neighborhood of approximately $3000 or more. Custom cushions are expensive because of the time consumed to make them and the cost of the relatively sophisticated equipment necessary to simulate individual anatomical contours of the user into a support contour of the custom cushion.

Connecting and adapting any of these seat cushions to a wheelchair seat support structure is not an insignificant matter. Each different type of wheelchair seat support structures usually requires a different type of attachment arrangement. Standard attachment hardware for each different type of wheelchair seat support structure is not readily available. Consequently, auxiliary attachment hardware and devices must be individually ordered or fabricated. Varying degrees

of functionality and success in attaching the seat cushion are common results in such circumstances. In general, the auxiliary attachment hardware adds weight to the wheelchair, making maneuverability of the wheelchair more difficult or strenuous.

Many of the same considerations also apply with varying levels of criticality to other uses of seat cushions. For example, seat cushions used in office environments are required to support the user in a comfortable manner which encourages proper posture and without creating risks of medical problems, for example inducing blood circulatory problems.

Summary of the Invention

The present invention obtains the benefits of a custom seat cushion at a modest fraction of the typical cost for a custom seat cushion, while simultaneously facilitating attachment and support of the cushion to a seat support structure. To do so, the seat cushion is formed in two portions. An upper human interface portion defines a support contour for the user's anatomy while seated. A lower base portion defines a contact configuration which complements and is supported against a seat support structure. The human interface portion and the base support portion are interconnected to complete the cushion.

The human interface portion is preferably formed with different support contours, thereby allowing human interface portion to be selected for use which best accommodates the anatomy of the user. A relatively small number of human interface portions, for example three, with different sized and shaped support contours will accommodate a significant population of users having normal anatomies. For those wheelchair users who have an abnormal anatomy, the human interface portion is formed with a specific custom support contour to accommodate the peculiarities of the abnormal anatomy. The lower base portion accommodates the user's preference for a type of seat support structure. Examples of wheelchair seat support structures include a platform seat, a sling seat, a dropped platform seat, a pan seat and a shell seat. A number of different base portions, each with a different contact configuration, allows the cushion to be used with any of the typical seat support structures without the need for cost of

additional parts and accessories. Interconnecting the upper human interface portion with the lower base portion allows the seat cushion to complement the anatomy of the user and the seat support structure without the need for and cost of additional parts and accessories.

The user can test or demonstrate the modular cushion to confirm that it provides the desired comfort and maneuverability prior to accepting the completed cushion. To the extent that testing demonstrates that changes are required, those changes may be achieved by interchanging one or both of the upper human interface and lower base portions. Future adjustments in the seat cushion can be accomplished by changing one or both of the upper human interface portion or the lower base portion to accommodate changes in the user's needs or preference for seat support structures, respectively. Because most of the human interface portions and the base portions are standard configurations, they can be mass produced for much less cost than if the entire cushion was custom made. In most cases, there is no need for a custom cushion, because a cushion can be assembled from standard variations of human interface portions. Furthermore, assembling the cushion from the standard human interface and base portions will make the completed cushion available for use on a more rapid basis.

One aspect of the invention involves a modular seat cushion which includes the human interface portion and the base portion. The human interface portion has an upper surface area defining a support contour for supporting an anatomical portion of the person while seated on the cushion. The human interface portion also has a lower surface area defining a first one of two complementary portions of an interlocking structure. The base portion has an upper surface area defining a second complementary portion of the interlocking structure and also has a lower surface area defining a contact configuration. The first and second complementary portions of the interlocking structure interconnect with one another when the lower surface area of the human interface portion contacts the upper surface area of the base portion. The contact configuration has a predetermined shape which complements at least a portion of the seat support structure.

Another aspect of the invention involves a method of creating a modular seat cushion. The method comprises selecting a human interface portion from among a plurality of different human interface portions which each have a different support contour, selecting a base portion from among a plurality of different base portions which each have a different contact configuration for a seat support structure, and combining the selected human interface portion with the selected base portion to position the support contour in complementary contact with the anatomical portion of the person and to position the contact configuration in complementary contact with the seat support structure.

Another aspect of the invention involves supporting a person on a seat support structure. This method comprises selecting the human interface portion with the desired support contour, selecting the base portion with the desired contact configuration, combining the selected human interface portion with the selected base portion, positioning the contact configuration into complementary contact with the seat support structure, and seating the person on the cushion with the anatomical portion of the person in contact with the support contour of the human interface portion.

Another aspect of the invention involves including in the seat support structure a portion which has essentially the same shape characteristics as the second complementary portion of the interlocking structure of the base portion, and then interfitting the selected human interface portion with the seat support structure.

Another aspect of the invention involves attaching a human interface portion of a seat cushion to a seat support structure of a wheelchair. The human interface portion includes a support contour for supporting an anatomical portion of a person on the seat cushion, and the seat support structure has a predetermined configuration for supporting the seat cushion and the person seated on the cushion. The method involves interposing a base portion between the human interface portion and the seat support structure of the wheelchair, interconnecting the base portion and the human interface portion, and contacting the base portion

in a complementary manner with the predetermined configuration of the seat support structure.

The present invention is particularly applicable to seat cushions for wheelchairs. Other preferable features of the invention involve forming the human interface and base portions from flexible support materials such as a resilient breathable plastic foam material, forming the complementary interlocking portions of the interlocking structure from the flexible support material, and employing consistent complementary portions of the interlocking structure so that the different human interface portions and base portions will interfit and connect together.

A more complete appreciation of the scope of the present invention and the manner in which it achieves the above-noted and other improvements can be obtained by reference to the following detailed description of presently preferred embodiments taken in connection with the accompanying drawings, which are briefly summarized below, and by reference to the appended claims.

Brief Description of the Drawings

Fig. 1 is an exploded and perspective view of a wheelchair and a modular seat cushion which incorporates the present invention, with a portion of the seat cushion shown broken away to show the internal structure of the seat cushion.

Fig. 2 is an enlarged and exploded downward-looking perspective view of the top of a top human interface portion and the top of a bottom base portion of the seat cushion shown in Fig. 1.

Fig. 3 is a upward-looking perspective view of the bottom of the top human interface portion and the bottom of the base portion shown in Fig. 2.

Fig. 4 is a longitudinal and vertical cross-sectional view of the seat cushion shown in Fig. 1 taken substantially in the plane of line 4-4, with the human interface and bottom support portions shown in an interconnected relationship.

Fig. 5 is an exploded front elevational view of a wheelchair having a platform seat support structure, and a wheelchair seat support cushion formed by a combined human interface portion and a base portion, as shown in Fig. 1, in which the base portion has a contact configuration which complements the platform seat support structure.

Fig. 6 is an exploded front elevational view of a wheelchair having a sling seat support structure, and a wheelchair seat cushion formed by a combined human interface portion and a base portion, similar to that shown in Fig. 1, in which the base portion has a contact configuration which complements the sling seat support structure.

Fig. 7 is an exploded front elevational view of a wheelchair having a dropped platform seat support structure, and a wheelchair seat cushion formed by a combined human interface portion and a base portion, similar to that shown in Fig. 1, in which the base portion has a contact configuration which complements the dropped platform seat support structure.

Fig. 8 is an exploded front elevational view of a wheelchair having a pan seat support structure, and a wheelchair seat cushion formed by a combined human interface portion and a base portion, similar to that shown in Fig. 1, in which the base portion has a contact configuration which complements the pan seat support structure.

Fig. 9 is an exploded front elevational view of a wheelchair having another pan seat support structure, different from that shown in Fig. 8, and a wheelchair seat cushion formed by a combined human interface portion and a base portion, similar to that shown in Fig. 1, in which the base portion is a part of the pan seat support structure.

Fig. 10 is an exploded front elevational view of a wheelchair having a shell seat support structure, and a wheelchair seat cushion formed by a combined human interface portion and a base portion, similar to that shown in Fig. 1, in which the base portion is a part of the shell seat support structure.

Fig. 11 is chart illustrating the combination of different human interface portions and base portions of the seat cushion shown in Figs. 1-10 to accommodate the different types of the wheelchair seat support structures shown in Figs. 5-10.

Detailed Description

A modular wheelchair seat cushion 20 is used with a seat support structure 22 of a conventional wheelchair 24 as shown in Fig. 1. One embodiment of the

seat cushion 20 comprises a human interface portion 26 and a base portion 28 which fit together in an interlocking manner, as shown in Figs. 1-4. Another embodiment of the seat cushion 20 interlocks the human interface portion 26 with a complementary portion of a seat support structure, as shown in Figs. 9 and 10. The human interface portion 26, and the base portion 28 (when used), are covered by a conventional covering 30 to complete the seat cushion 20.

An upward-facing support contour 32 is formed in the human interface portion 26 to support the user when the user sits on the cushion 20, as shown in Figs. 1, 2 and 4. Different human interface portions 26 will each have differently-shaped support contours 32 to accommodate the different anatomies of different users, when the user sits on the support contour 32 of the cushion 20.

The base portion 28 includes a downward-facing contact configuration 34 which interacts with a particular type of seat support structure 22. Examples of different types of wheelchair seat support structures 22 are a platform seat 36, shown in Figs. 1, 4 and 5; a sling seat 38, shown in Fig. 6; a dropped platform seat 40, shown in Fig. 7; a pan seat 42, shown in Fig. 8; another type of pan seat 44, shown in Fig. 9; and a shell seat 46, shown in Fig. 10. All of these wheelchair seat support structures 36-46 are typically connected to longitudinally extending rails 48 of a frame 50 of the wheelchair 24.

The interaction of the contact configuration 34 of the base portion 28 with the seat support structure 22 maintains the cushion 20 in place on the wheelchair 24, in one embodiment of the invention. In the other embodiment of the invention, the human interface portion 26 directly interacts and complements a particular type of seat support structure 22 without the use of a separate base portion 28 of the cushion 20. In this second embodiment, the portion of the human interface portion 26 which normally interacts directly with the base portion 28 instead directly interacts with the seat support structure 22 to hold the human interface portion 26 in the seat support structure 22 without the need of a separate base portion 28. The covering 30 typically extends only over the human interface portion 26, in this second embodiment.

By employing a particular support contour 32 of the human interface portion 26 which comfortably fits and supports the anatomy of a particular user, and by selecting a base portion 28 or human interface portion 26 which has a contact configuration that matches and conforms with the type of wheelchair seat support structure 22, a wheelchair seat cushion 20 is obtained which offers significant benefits for the user. The comfort and fit of the support contour 32 offers the capability for significant freedom from pressure ulcers. The cushion allows enhanced maneuverability, stability and use of the wheelchair. These benefits are available from any wheelchair having any of the common and conventional seat support structures 22. By mass producing different human interface portions 26 with different support contours 32 and by mass producing different base portions 28 with different contact configurations 34, and by then combining the human interface portions 26 according to the anatomy of the user with the base portions 28 according to the different types of wheelchair seat support structures 22, the resulting cushion 20 can very closely simulate the benefits of a custom wheelchair cushion, but without the added cost of a custom wheelchair cushion. When a custom cushion is required or desired by the user, only the support contour 32 of the human interface portion 26 must be specially fabricated, and not the entire cushion, since a standard base portion 28 can be used with the specially fabricated human interface portion 26. Standard contact configurations 34 make retention on the wheelchair seat support structure relatively easy to accomplish without incurring the cost and effort of modifying a cushion to accommodate a particular wheelchair support structure and without fabricating or using additional support and retention hardware.

The human support contour 32 of the human interface portion 26 is illustrated in Figs. 2 and 4. The support contour 32 may be shaped to accommodate a normal human anatomy, with only the size and proportion of the support contour 32 adjusted to accommodate different sizes and shapes of users. The support contour 32 of the human interface portion 26 may also be formed in a custom configuration to accommodate the specific anatomical uniqueness of a user who may not fit or prefer a standard variation support control 32.

Preferably, the shape and proportion of the standard variations in the support contour 32 will be as described in U.S. patent application Serial No. [249.303], referenced above. The support contour described in this U.S. patent application has considerable advantages and improvements in avoiding pressure ulcers while providing improved postural alignment for the user. Adjusting the size and proportion of this standard support contour 32 accommodates different sizes and shapes of the normal anatomy. For example, one standard variation of the support contour 32 is intended to primarily accommodate the wider spread and shallower slope of the ischial tuberosities of the female skeletal bone structure. Another standard variation of the support contour 32 is intended to accommodate the narrower and steeper slope of the ischial tuberosities of the male skeletal bone structure. Another standard variation of the support contour 32 is not gender-specific, but has a deeper and steeper profile. This deeper and steeper support contour 32 may provide better protection for individuals with soft tissue atrophy. However, regardless of sex or degree of tissue atrophy, any user may prefer any one of these different standard variations of support contours, depending on personal comfort, support and preference.

In general, a variety of different support contours and theories for supporting wheelchair users are known and available, in addition to the subject matter described in U.S. application Serial No. [249.303]. Any type of support theory can be implemented in the support contour 32 of the human interface portion 26, in accordance with the present invention.

In those cases where an individualized or custom support contour 32 is desired, that custom support contour 32 must be derived and made from the particular anatomical characteristics of the individual user. A number of known techniques are available to create custom wheelchair cushions, and those known techniques may be applied to create the support contour 32 and the human interface portion 26 in accordance with the invention. One particularly useful type of technique for creating a seat cushion is described in U.S. patent application Serial No. [249.301], referenced above. That technique is applicable to fabricating both the human interface portion 26 and the base portion 28.

The human interface portion 26 and the base portion 28 are interconnected mated or interfitted together by an interlocking structure 52. One example of an interlocking structure 52 is shown in Figs. 2-4. The interlocking structure 52 includes a protrusion 54 which extends downward (as shown) from a lower surface 56 of the human interface portion 26. The protrusion 54 fits within a complementary shaped recess 58 formed into the base portion 28 from an upper surface 60 of the base portion. The lower surface 56 of the human interface portion 26 and the upper surface 60 of the base portion 28 are shaped in a mutually complementary manner, as shown in Fig. 4. The surfaces 56 and 60 contact one another when the protrusion 54 fits within the recess 58. The complementary interfitting relationship of the protrusion 54 within the recess 58, and the complementary interfacing contact of the surfaces 56 and 60, interlock the human interface portion 26 with the base portion 28, as shown in Fig. 4. When interlocked in this manner, the portions 26 and 28 will not readily separate, particularly when covered or encased with a relatively tight covering 30 (Fig. 1) or when held together with adhesive. Although not shown, other indexing configurations or shapes may be formed on the surfaces 56 and 60 to interfit with one another, to supplement and/or substitute for the interfitting relationship of the protrusion 54 and the recess 58.

The interlocking structure 52 is of a consistent configuration among all of the different types of human interface portions 26 and base support portions 28. The protrusion 54 and the lower surface 56 of the human interface portion 26 have consistent shapes and dimensions on all of the different types of human interface portions 26. Similarly, the recess 58 and the upper surface 60 of the base portion 28 have consistent shapes and dimensions on all of the base portions 28. Consequently, any of the different types of human interface portions 26 will interconnect, mate and interfit with any of the different types of the base portions 26.

Depending upon the thickness of the base portion 28, the recess 58 may extend completely through the base portion 28, in which case the recess 58 constitutes a hole completely through the base portion 28 as shown in Figs. 2 and

4. In this embodiment when the portions 26 and 28 are interlocked and placed on the seat support structure 22 of the wheelchair, the protrusion 54 contacts and rests against the seat support structure 22, separated only by the thickness of the covering 30. Using a hole as the recess 58 in the base portion 28 configuration allows the human interface portion 26 to have a relatively deep support contour 32 while still interfitting with the base support portion 28, and to maintain as low of a center of gravity of the user as possible.

The contact configuration 34 of the base portion 28 includes a lower surface 62 (Figs. 3 and 4) which substantially fully contacts and complements one type of wheelchair seat support structure 22. The common and prevalently used types of wheelchair seat support structures 22 are illustrated in Figs. 5-10.

A typical platform wheelchair seat support structure 36 is shown in Figs. 1, 4 and 5. The platform seat support structure 36 is formed by a rigid, generally planar sheet member 64 which extends between the rails 48 of the wheelchair frame 50. For example, the sheet member 64 may be formed from plywood, metal, or composite material. The sheet member 64 is attached to the rails 48 by conventional fasteners (not shown). The upper surface of the sheet member 64 is planar. To fully contact and complement the upper planar surface of the sheet member 64, the contact configuration 34 of the base portion 28 is made as a planar surface 62a, shown in Fig. 5. When a base portion 28 with a lower planar surface 62a rests on the upper planar surface of the sheet member 64, the shape of the recess 58 and upper surface 60 (Figs. 2 and 4) are not distorted from their intended shapes, thereby allowing the protrusion 54 and the lower surface 56 to fit within and contact the recess 58 and the upper surface 60, respectively, to interlock the human interface portion 26 and the base portion 28.

A typical sling seat 38 is another type of wheelchair seat support structure 22, shown in Fig. 6. The sling seat 38 is formed by strong and flexible material 66, such as durable fabric, which is connected or suspended in a sling-like manner between the rails 48. The material 66 is connected to each of the rails 48 by looping each end of the material 66 around a longitudinally-extending support bar (not shown) and then connecting each end of the material 66 to the middle portion

of the material 66 with a conventional hook and loop fastener. The longitudinally extending support bar (not shown) is then attached to the rails 48 with conventional fasteners (not shown).

In general, the sling seat 38 will sag or curve downward between the rails 28 as generally shown in Fig. 6. Consequently, in order to fully contact and complement the curved shape of the material 66 forming the sling seat 38, the contact configuration 34 of the base portion 28 is formed with a complementary downwardly-curved convex lower surface 62b shown in Fig. 6. When a base portion 28 with the downwardly-curved lower surface 62b rests on the downwardly curved material 66 of the sling seat 38, the shape of the recess 58 and upper surface 60 (Figs. 2 and 4) are not distorted from their intended shapes, thereby allowing the protrusion 54 and the lower surface 56 to interfit with the recess 58 and the upper surface 60, respectively, and thereby interconnect the human interface portion 26 and the base portion 28.

A typical dropped platform wheelchair seat support structure 40 is shown in Fig. 7. The dropped platform seat 40 is similar to the platform seat 36 (Fig. 5), except that the dropped platform seat 40 is suspended beneath and between the rails 48. The dropped platform seat 40 is formed by a rigid, generally planar sheet member 70 which is suspended from the rails 48 by suspension brackets 72. For example, the sheet member 70 may be formed from plywood, metal or composite material. Conventional fasteners (not shown) connect the suspension brackets 72 to the sheet member 70 and connect suspension brackets 72 to the rails 48. The upper surface of the sheet member 70 is planar, and the upper surface is located at a position lower than the rails 48 of the wheelchair frame 50 (Fig. 1).

To fully contact and complement the upper planar surface of the sheet member 70, and to extend over the top of the rails 48, the contact configuration 34 of the base portion 28 is formed as a lower planar surface 62c with longitudinal edge recesses 74 extending along each transverse side of the base portion 28. The recesses 74 fit around the suspension brackets 72 and the rails 48, thereby allowing a portion of the base support 28 to extend over and around the rails 48. When a base portion 28 with a planar lower surface 62c and recesses 74 rests on

the planar surface of the sheet member 70 and fits around the suspension brackets 72 and the rails 48, the shape of the recess 58 and upper surface 60 (Figs. 2 and 4) are not distorted from their intended shapes, thereby allowing the protrusion 54 and the lower surface 56 to interfit with the recess 58 and the upper surface 60, respectively, and thereby interconnect the human interface portion 26 and the base portion 28.

A pan seat 42, shown in Fig. 8, is another type of wheelchair seat support structure 22. The pan seat support structure 42 may take a variety of different configurations. In general, the pan seat 42 will always include a bottom wall 76 which extends between the rails 48. The bottom wall 76 may be generally planar, as shown in Fig. 8, or the bottom wall 76 may curve slightly downward similar to the curve of the sling seat 38 (Fig. 6). The pan seat 42 may also include edges 78 which extend upward from the periphery of the bottom wall 76. The edges 78 will not extend along a front edge of the bottom wall 76 where the legs of the user will bend when the user is seated in the pan seat 42. The pan seat 42 is preferably formed of rigid material, for example lightweight composite material. The pan seat 42 is attached to the rails 48 by conventional fasteners (not shown) or rests on the sling seat 38 (Fig. 6) with hook and loop attachment. In a sense, the pan seat 42 is similar to the platform seat 36 (Fig. 5), except that it may also include the edges 78 and may have a curved bottom wall 76.

The contact configuration 34 of the base portion 28 is formed as a surface 62d which has been curved and shaped in a manner to fully contact and complement any curvature and shape of the bottom wall 76. The base portion 28 should also be shaped to fit within the edges 78. When a base portion 28 with an appropriately-shaped contact surface 62d rests on the bottom wall 76 and within the edges 78, the recess 58 and upper surface 60 (Figs. 2 and 4) are not distorted from their intended shapes, thereby allowing the protrusion 54 and the lower surface 56 to interfit with the recess 58 and the upper surface 60, respectively, and interconnect the human interface portion 26 and the base portion 28.

Another type of pan seat wheelchair support structure 44 is shown in Fig. 9. The pan seat 44 is similar to the pan seat 42 (Fig. 8) but includes a receptacle 82

formed in a bottom wall 84 of the pan seat 44. The receptacle 82 has the shape and configuration of the recess 58 of the base portion 28 (Figs. 2 and 4). In addition, the upper surface of the bottom wall 84 which surrounds the receptacle 82 has the shape and configuration of the upper surface 60 of the base portion 28 (Figs. 2 and 4). Shaped in this manner, the receptacle 82 and the upper surface of the bottom wall 84 are capable of interconnecting in a complementary manner with the protrusion 54 and the lower surface 56 of the human interface portion 26 (Figs. 3 and 4).

The human interface portion 26 is interconnected directly with the pan seat 44 as a result of the protrusion 54 of the human interface portion 26 extending into the receptacle 82 and the lower surface 56 of the human interface portion 26 (Figs. 2-4) resting on the bottom wall 84 of the pan seat 44. Use of the base portion 28 (Figs. 1-4) is unnecessary because a portion of the seat pan 44 becomes the base portion 26. Interconnecting the complementary portions of the human interface portion 26 and the seat pan 44 interlocks the human interface portion 28 and the pan seat 44.

The pan seat 44 is attached to the rails 48 with fasteners (not shown). The pan seat 44 may also include edges 78 which extend upward from the periphery of the bottom wall 84, except that the edges 78 will not extend along a front edge of the bottom wall 84 where the legs of the user will bend when the user is seated in the pan seat 44. In the embodiment shown in Fig. 9, only the human interface portion 26 is enclosed within a covering 30.

A complete shell seat 46 is another type of wheelchair seat support structure 22, as shown in Fig. 10. The shell seat support structure 46 includes a bottom wall 86 which may be similar in shape and configuration to one of the bottom walls 76 and 84 of the pan seats 42 and 44 (Figs. 8 and 9), respectively. In addition, the shell seat 46 includes a back wall 88 which extends vertically upward from the bottom wall 86 at a location to contact the back of the upper torso of the wheelchair user. The shell seat 46 may also include edges 78 which extend longitudinally on opposite transverse sides of the bottom wall 86, from the back wall 88 forward. Preferably, the entire shell seat 46 is formed as a rigid integral

structure of lightweight composite material. The shell seat rests on a sling seat 66 of a typical wheelchair and an anchoring strap 89 secures the seat to the wheelchair.

Depending upon the shape and configuration of the bottom wall 86, the cushion 20 used with the shell seat 46 may or may not include a base portion 28 (Figs. 1-4). If the bottom wall 86 has a configuration similar to the bottom wall 76 of the pan seat 42 shown in Fig. 8 but not shown in Fig. 10, the contact configuration 34 of the base portion 28 will be formed as a lower surface 62 which has a shape which complements the bottom wall 86. If the bottom wall 86 has a configuration similar to the bottom wall 84 of the pan seat 44 shown in Fig. 9 and also shown in Fig. 10, and thereby includes the receptacle 82, the base portion 28 will not be part of the cushion 20. Instead, the human interface portion 26 will interconnect directly with the bottom wall 86. Whether or not a base portion 28 is used, the human interface portion 26 will be retained within the shell seat 46. Although not shown in Fig. 10, a cushion or other type of padding will typically be attached to the back wall 88 to provide comfort, support and protection for the upper torso of the user.

The human interface portion 26 and the base portion 28 may be formed of flexible support material such as moldable plastic foam. One particularly advantageous type of material from which to make the human interface portion 26 and the base portion 28 is plastic beads, as described more completely in U.S. patent applications Serial Nos. [249.301 and 249.303]. The plastic bead material is fused together in such a way that spaces exist between the individual fused beads. The spaces between the individual fused beads make the portions 26 and 28 breathable in the sense that air will move through them, thereby providing ventilation through the cushion to the user. In addition, the base portion 28 may be formed somewhat more rigidly and having less flexibility than the human interface portion 26, to add structural stability to the cushion 20. The human interface portion 26 may be somewhat more flexible to accommodate interaction with the user's anatomy. The differences in flexibility and rigidity may be accommodated by using different sizes and resiliencies of plastic beads and different degrees of

compaction of those plastic beads when fusing them together, as described in U.S. patent applications Serial Nos. [249.301 and 249.303].

The human interface portion 26 and the base portion 28 may be permanently connected or held together with an adhesive. However, due to the interlocking structure 52 shown in Figs. 2-4, the portions 26 and 28 may also be held together by a closely-surrounding or encasing covering 30. Holding the portions 26 and 28 together in a nonpermanent manner allows each of the individual portions 26 and 28 to be changed as necessary to accommodate changing needs of the user and changes in preferences for seat support structures.

The covering 30 can be any type of impervious material, if a liquid resistant seat cushion 20 is required. However, to take advantage of the breathable characteristics of the portions 26 and 28, the covering 30 is preferably a fabric or some other type of material which allows air to pass through it.

The chart shown in Fig. 11 illustrates the interchangeability of the human interface portions 26 and the base supports 28 with different wheelchair seat support structures. The different types of human interface portions discussed above are generally represented by the left-hand column in Fig. 11. These types of human interface portions 26 each include a different variation of the support contour 32 (Figs. 2 and 4). Those standard variations are represented by a female variation support contour 90, a male variation support contour 92, and a non-gender-specific contour 94 which is intended to accommodate greater degrees of tissue atrophy. All of these support contours have been discussed generally above. The human interface portion 26 may also use a custom support contour 96 which is configured to interface specifically with the anatomy of a particular individual, as also discussed above. The right hand column in Fig. 11 represents the different types of configurations 34 of the base portions 28 which may be used to accommodate the different types of common wheelchair seat support structures or which may be part of the wheelchair seat support structures. Those types of different seat support structures include the platform seat 36 (Figs. 1 and 5), the

sling seat 38 (Fig. 6), the dropped platform seat 40 (Fig. 7), the pan seats 42 and 44 (Figs. 8 and 9) and the shell seat 46 (Fig. 10).

By using the human interface and base portions 26 and 28 in connection with any of the seat support structures 22 in the manner described, the resulting seat cushion 20 provides support for the wheelchair user while offering a high level of relative protection to the wheelchair user against pressure ulcers. Simultaneously, the needs and preferences of the user are accommodated with respect to a particular type of seat support structure on a particular type of wheelchair. These benefits are obtained without the need for additional hardware and attachment accessories that add to the cost of the cushion and the weight of the wheelchair. Moreover, the modularity and interfitting relationship of the seat cushion offers a relatively inexpensive and effective way to provide a highly functional seat cushion which closely approximates the benefits of a custom seat cushion. For those users who require or desire a custom seat cushion, the custom human interface portion may still be interconnected with a standard base portion to obtain the benefits of standard base variations. A relatively few variations of human interface portions 26 and base portions 28, represented in Fig. 11, will accommodate the substantial majority of the seat support structures which are commonly and prevalently available for use by wheelchair users.

Most of the same improvements are applicable to use of the present invention for seat cushions in environments other than wheelchair seat cushions, for example chairs used in office environments. A desired type of human interface portion 26 may be selected according to the preferences of the user, and the type of base portion 28 is selected according to the type of seating structure upon which the user prefers to connect the human interface portion 26. In this manner, the benefits of the human interface portion for supporting the user are available on a variety of different types of seating devices and structures. Many other advantages and improvements will be apparent upon comprehending the full significance of the present invention, not only for use with wheelchairs but for other applications as well.

Presently preferred embodiment of the invention and many of its improvements have been described with a degree of particularity. This description is of preferred examples of implementing the invention, and is not necessarily intended to limit the scope of the invention. The scope of the invention is defined by the following claims.